



APPLICATION NO. 09/826,118

TITLE OF INVENTION: Wavelet Multi-Resolution Waveforms

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Currently amended CLAIMS



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## CLAIMS

WHAT IS CLAIMED IS:

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Claim 1. (deleted)

Claim 2. (deleted)

Claim 4. (deleted)

Claim 5. (deleted\_

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Claim 6. (deleted)

Claim 7. (currently amended) A least-squares method for generating and applying Wavelet waveforms and filters, said method comprising the steps:

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said Wavelet is a digital finite impulse response waveform at baseband in the time domain,

linear phase finite impulse response filter requirements on the passband and stopband performance of the power spectral density are specified by linear quadratic error metrics in the Wavelet,

25

Wavelet requirements on the deadband for quadrature mirror filter properties required for perfect reconstruction are specified by a linear quadratic error metric in the Wavelet,

30

Wavelet ~~orthogonality~~ orthogonality requirements for intersymbol interference\_ and adjacent channel interference are specified by non-linear quadratic error metrics in the Wavelet,

35

non-linear quadratic error metrics have quadratic coefficients dependent on the Wavelet,

Wavelet multi-resolution property requires said error metrics to be converted to error metrics in the discrete Fourier transform harmonics of the Wavelet which harmonics are the Wavelet impulse response in the frequency domain,

- 5 using a least-squares recursive solution algorithm ~~in figures 4,5~~ with quadratic error metrics, which algorithm requires a means to find the Wavelet harmonics that minimize the sum of said linear quadratic error metrics, ~~an example means being the eigenvalue algorithm,~~
- 10 said harmonics are used to linearize said non-linear quadratic error metrics,
- said least-squares recursive solution algorithm finds the harmonics which minimize the weighted sum of the linear and linearized quadratic error metrics,
- 15 said least-squares recursive solution algorithm starts over again by using said harmonics to linearize the non-linear error metrics and to find the corresponding harmonics which minimize the sum of said linear and linearized quadratic error metrics,
- 20 said least-squares recursive solution algorithm continues to be repeated until the solution converges to the design harmonics of the Wavelet which is the least-squares error solution, and
- said Wavelet impulse responses in the time domain and
- 25 frequency domain are implemented in communication systems for waveforms and filters.

Claim 8. (currently amended) A second least-squares method

30 for generating and applying Wavelet waveforms and filters, said method comprising the steps:

linear phase filter requirements on the passband and stopband performance of the power spectral density are specified by linear quadratic error metrics in the Wavelet impulse

35 response in the time domain,

using a least-squares recursive solution algorithm ~~in figures 4,5~~  
with norm-squared error metrics, which algorithm requires  
a initialization Wavelet and a means to find the Wavelet  
harmonics which minimize the sum of said linear norm-  
5 squared error metrics, ~~an example means being a gradient~~  
~~search algorithm,~~

said initialization Wavelet is the optimum Wavelet that minimizes  
the weighted sum of said linear quadratic error metrics  
which optimum Wavelet is found using an eigenvalue, Remez-  
10 Exchange, or other optimization algorithm,

said linear quadratic error metrics are transformed into linear  
norm-squared error metrics in the Wavelet,

Wavelet requirements on the deadband for quadrature mirror filter  
properties required for perfect reconstruction are  
15 specified by a linear norm-squared error metric in the  
Wavelet,

Wavelet orthogonality requirements for intersymbol interference  
and adjacent channel interference are specified by non-  
linear norm-squared error metrics in the Wavelet,

20 non-linear norm-squared error metrics have norm coefficients  
dependent on the Wavelet,

Wavelet multi-resolution property requires said error metrics to  
be converted to error metrics in the discrete Fourier  
transform harmonics of the Wavelet which harmonics are the  
25 Wavelet impulse response in the frequency domain,

using said least-squares recursive solution algorithm to find the  
harmonics that minimize the weighted sum of said least-  
squares linear and non-linear norm-squared error metrics,  
which harmonics are the design harmonics of the Wavelet  
30 least-squares error solution, and

said Wavelet impulse responses in the time domain and frequency  
domain are implemented in communication systems for  
waveforms and filters.

Claim 9. (deleted)

Claim 10. (currently amended) Wherein applications of the Wavelet waveforms and filters in claims 7 or 8, comprising:

- 5 Discrete Fourier Transform (DFT) defines the mother Wavelet in terms of the frequency domain design harmonics in equation (11),  
mother Wavelets for scale and translation parameters are defined in terms of the design harmonics in equation (18),  
10 mother Wavelet design harmonics are defined in terms of the Wavelet impulse time response digital samples in equation (20),

Wavelet design in the frequency domain allows a mother Wavelet to be re-scaled for application to multi-channel polyphase  
15 filter banks by implementing equations (11), (18), (20) which derive a multi-resolution Wavelet from a mother Wavelet by using the design harmonics of the mother Wavelet and the multi-scale parameters of the Wavelet impulse response for said application,

20 wherein mother Wavelet refers to a Wavelet at baseband which is used to generate other Wavelets,

wherein multi-scale parameters are the traditional scale, translation, timing parameters, plus ~~the new~~ frequency, spacing, and length parameters of this invention, and  
25 wherein

scale parameter scales ~~the sampling~~ time interval between samples, ~~the sub-sampling, the over-sampling, and the translation interval between Wavelets,~~  
translation parameter is the timing offset of the Wavelets  
30 in units of the spacing parameter,  
timing parameter is the digital sampling interval,  
frequency parameter is a frequency offset which translates the Wavelet in frequency,  
spacing parameter is the number of digital samples for

Wavelet\_spacing which is equal to the number of  
channels in a polyphase filter bank with a Nyquist  
sampling rate,  
length parameter specifies the length of the Wavelet in the  
5 sampling domain, and  
said multi-scale parameters and the mother Wavelet design  
harmonics generate the Wavelet for the multi-channel  
polyphase filter bank.

10 Claim 11. (deleted)

Claim 12. (currently amended) Wherein properties of Wavelet  
15 waveforms and filters in claims 7 or 8, comprising:

Discrete Fourier Transform (DFT) defines the mother Wavelet in  
terms of the frequency domain design harmonics in equation  
(11),

mother Wavelets for scale and translation parameters are defined  
20 in terms of the design harmonics in equation (19),

mother Wavelet design harmonics are defined in terms of the  
Wavelet impulse time response digital samples in equation  
(20),

said Wavelets are multi-resolution Wavelets which enable a  
25 single Wavelet design at baseband to be used to generate  
Wavelets for multi-resolution applications by implementing  
equations (11), (18) (20) and using the Wavelet design  
harmonics and the multi-scale parameters for the multi-  
resolution Wavelet applications,

30 said Wavelet ~~can be~~ is designed for a communications waveform with  
no excess bandwidth,

said multi-resolution Wavelets are designed to behave like  
an accordion in that at different scales the Wavelet is a  
stretched or compressed version of the Wavelet, ~~with~~

~~appropriate time and frequency translation as disclosed on  
page 21,~~

said linear waveform and filter least-squares design methods ~~can~~  
~~be~~are modified to design non-linear Wavelet waveforms for  
5 other applications including bandwidth efficient modulation  
and synthetic aperture radar, ~~as demonstrated in figures~~  
~~7,8,~~ and

other optimization algorithms exist for finding said Wavelets.

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